

PARAMETERS FOR MACHINING NIOBIUM AT FNAL

High RRR niobium is very soft and acts like soft copper or lead. A lot of data can be found on the web, e.g. at

<http://www.wahchang.com/WahChang/pages/products/data/pdf/Niobium%20Machining%20&%20Forming%20Operations.pdf>

but they rather apply to Nb alloy like NbTi, or commercial Nb. High purity Nb is discussed below.

We summarized here the information coming from the actual experience at Fermilab + some data from literature.

Machining:

Niobium has a tendency to gall or to seize to tooling; special attention must be given to tool angles and lubrication. Tools must be very sharp and high speed, steel rather than carbide tools are recommended. Compare to data provided in literature, speed must be increased by a large factor when dealing with high RRR material.

Fermilab experience with machining niobium on a lathe has determined that the primary points to emphasize are:

- (1) Always keep tools sharp,
- (2) Use manual feed (rate at operator's discretion) to peel niobium chips away from the part as rapidly as possible, and
- (3) Employ high cutting speeds.

Niobium chips have a tendency to curl back toward the part. This tendency increases as the part heats up. If chips are allowed to contact the part they will most likely friction weld to the part material.

FNAL generally uses only high-speed steel tools for lathe turning niobium components. Typical cutting speed is 250 – 270 rpm. This translates to a range of approximately 80 – 200 ft/min, depending on the part diameter. Alcohol is used as a lubricant. There is one exception to the use of high-speed steel tools. A very sharp carbide insert is used for weld prepping half-cell equators. Cutting speeds are in the range of 350 – 400 rpm (280 – 320 ft/min).

The tools are ground by hand. Typical tool geometry is shown in Figure 1.



Figure 1

Forming

In case of high pressure forming operations (e.g. spinning, heavy deep drawing) niobium has tendency to stick to tooling during; specific lubricant and die material must be considered: brass, bronze ; (Be-Cu or steel have also been mentioned). In the case of lesser deformation, as for instance half cell deep drawing or hydroforming, aluminum tools are commonly used without reported trouble. At Fermilab, dies and coining rings for forming half-cells are machined from 7075-T6 aluminum. Mobil DTE Light machine oil is used as a lubricant.

Lubricant: discussion

There are many discussions about the choice of a proper lubricant and its interaction with niobium surface. Nevertheless one cannot hinder some surface contamination and cold working upon any type of forming of niobium. Priority should be given in accordance to the ensuing cleaning procedure.

Therefore silicon type oil should be prohibited, as it is very difficult to eliminate. Light hydrocarbon molecules that can be efficiently rinsed/degreased should be preferred (e.g. ethanol, water soluble hydrocarbon...).

As particle contamination is also an issue in SRF application, lubricant with particles suspension like graphite or MoS₂ should also be avoided as possible, although appropriate cleaning procedure should be able to overcome this problem.

One expects any organic lubricant to react with freshly cut Nb surface, but this pollution should remain very superficial and subsequent chemical etching should get rid of the contaminated surface.